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A drive train of an all-wheel drive vehicle

The invention relates to a drive train of an all-wheel drive vehicle consisting of a transfer case adjoining the engine transmission block, a driven front axle and a driven rear axle, the drive shafts leading from the transfer case to the axles and a control device, with the torque metered to the drive shafts being able to be regulated by variable loading of friction couplings.

In currently common drive trains of all-wheel vehicles, only the torque channeled off for the drive of the front axle is controlled by means of a friction coupling. In all-wheel vehicles of the latest generation, however, the torque metered to both axles should be controllable over the total range from 0 to 100 percent. In this manner, the torque metered to the front axle cannot only be regulated in a range from zero up to a proportion fixed by the design and manner of construction, which lies at around 50%, but from 0 to 100%, that is from purely rear wheel drive to purely front wheel drive. All-wheel drive can thus also satisfy all dynamic driving demands and safety demands for fast road driving beyond off-road operation. This also includes the compatibility with electronic systems which act on the brakes of the vehicle. The term "torque vectoring" has become common for this in the technical world.

A drive train of this type is known, for instance, from US 4,709,775. In this, the transfer case adjoining the engine transmission block contains two friction couplings, one in the path to the drive shaft of the front axle and one in the path to the drive shaft of the rear axle. Transfer cases of this type are bulky, expensive and complex assemblies. Above all the

substantial requirement of construction space is very problematic subsequent to the transmission, where it is anyway very tight.

A drive train for all-wheel vehicles having two or even four coupling units which meter a regulatable torque to each axle or to each individual wheel, is known from DE 38 14 435 Each coupling unit consists of a controllable liquid friction coupling and of a friction coupling which can be engaged and disengaged, that is a non-controllable friction coupling, for the bridging of the first. The construction effort and the space requirements as well as the regulation problems of this solution are prohibitive. Due to the diversion via the controllable liquid friction coupling, an accurate and fast control is also not even possible.

A drive train is known from US 5,119,298 comprising a transfer case which drives through rigidly to the rear axle and channels off the torque for the front axle by means of the friction coupling. This drive train belongs to the older generation of drive trains which do not permit any variation in the torque distribution between 0 and 100%, but it does show the construction of a transfer case customary in such drive trains.

It is therefore the aim of the invention to set forth a drive train which permits the variation of the torque distribution between 0 and 100% with a simpler and more space-saving construction and low costs, and indeed fast and accurately.

In accordance with the invention, this is achieved in that the transfer case has a drive through shaft which is connected drivewise to the engine transmission block, one the one hand, and to the drive shaft leading to the rear axle, on the other hand, said drive through shaft being connected drivewise to the drive through shaft leading to the front axle via a coaxial

friction coupling determining the torque metered to the front axle and via an offset drive and in that a further regulatable drive unit having a friction coupling is provided at the rear axle which regulates the torque metered to the rear axle.

A customary transfer case such as is used in drive trains of the older generation without the torque distribution variable between 0 and 100 percent can thus be used as the transfer case.
They are thereby tested drive components which are cheap due to the large volumes and which take up only a little construction space in the longitudinal direction of the vehicle and upwardly. The further regulatable drive unit having a friction coupling at the rear axle can be of any desired construction type and actuation type; it can easily be accommodated in the vicinity of the rear axle differential. In addition, a better axle load distribution is also thereby attained.

The actuators of the two friction couplings are preferably of the same type and are controlled from a common control device (claim 2). Actuators of the same type respond to control signals of the same type. A single control device which controls both couplings simultaneously is thereby sufficient.

In a preferred embodiment, the further friction coupling is drive connected to the first drive shaft, on the one hand, and to the differential of the rear axle, on the other hand, and is accommodated in a housing in a unit construction block with the housing of the differential (claim 3). The construction combination in one housing complex provides further economy of space and a reduction in costs by a common utilization of bearings and lubrication devices.

In a further development of the invention and while utilizing the possibilities opened up by it, the couplings can be designed such that the transfer casing and the drive unit have a number of same parts (claim 4). These can be mechanical parts of the coupling, the actuators and, with correspondingly disposed separation joints, also housing parts. It is also within the framework of the invention to provide a parking lock gear, downstream of the friction coupling in the force-flow direction, in the transfer case or in the drive unit with the further friction coupling (claim 5). Such a one is considered necessary in drive trains without a compulsory connection to the road as a safety measure. This is also why it is disposed downstream. It can be accommodated particularly practically here or there in a drive train in accordance with the invention.

The invention will be described and explained in the following with reference to Figures. There are shown:

Fig. 1: schematically, a drive train in accordance with the invention;

Fig. 2: details A and B enlarged and in somewhat more detail.

In **Fig. 1**, an all-wheel drive motor vehicle is reduced to its drive train. An engine transmission unit 1 is connected to a transfer case 2. A first drive shaft 3 leads from this to the rear axle 4 and a second drive shaft 5 leads from this to the front axle 6. The first drive shaft 3 leads into a drive unit 7 which is adjoined by a rear axle drive 8 with a rear wheel differential for the drive of the wheels of the rear axle 4. The second drive shaft 5 leads into a front axle drive unit 9 with a front axle differential.

The transfer case 2 and the drive unit 7 include controllable couplings (see Fig. 2) which can each be actuated by means of a first actuator 11 and of a second actuator 12. Position sensors 13, 14 are attached to the actuators 11, 12. They generate position signals for a common control device 15 which controls the actuators 11, 12. The control device 15 is connected via a CAN bus 16 to, inter alia, an ABS control device 17 or another electronic brake or drive stability control.

In **Fig. 2**, the transfer case 2 and the drive unit 7 are shown somewhat more accurately, with bearings and details not essential to the invention, however, being omitted. The first drive shaft 3 and the second drive shaft 5 are shown broken open here and are connected via universal joints 3' 5' or the like to the transfer case 2 or the drive unit 7. The transfer case 2 is accommodated in a housing 20 connected to the engine transmission block 1 by means of a flange 21. A first coupling 23 is arranged on a drive through shaft 22 and is a friction coupling having multiple inner or outer disks. It furthermore consists of a coupling bell 24, rotationally fixedly connected to the drive through shaft 22, on the primary side, and of an inner coupling part 25 ,on the secondary side, which is a hollow shaft supported on the drive through shaft 22 here. The hollow shaft is rotatably fixedly connected to or integral with a first sprocket 26 which, via a chain 27 or the like, drives a second sprocket 28 which is rotationally fixedly connected to the second drive shaft 5. The sprockets 26, 28 and the chain 27 form an offset drive which could equally easily be made only by toothed wheels or other transmission means. The coupling 23 is actuated by the actuator 11, for example, via articulated jacks 32 and ramp rings 31.

The drive unit 7 is accommodated in a housing 40 which is integral with or fixedly connected to a housing 41 of the rear axle drive 8. The first drive

shaft 3 merges here, at the universal joint 3' into an input shaft 42 which leads to a second coupling 43 which is again also a friction coupling with multiple inner and outer disks. It furthermore consists of a coupling bell 44 rotationally fixedly connected to the input shaft 42 and of an inner coupling part 45 which simultaneously forms the shaft for a pinion 46 which acts on the rear axle differential 48 via a ring gear 47. This coupling is actuated in a controlled manner by the second actuator 12 via a lever 52 and ramp rings 51.

It can also be recognized in **Fig. 2** that the two controllable friction couplings 23, 43 are of the same construction, apart from the difference between the inner coupling part 25 of the first coupling 23 and the inner coupling part 45 of the second coupling 43 forming the pinion shaft. The actuators 11, 12 and the levers 32, 52 as well as the ramp rings 31, 51 are likewise identical components.
Overall, a simple and nevertheless complete solution is provided by the division of the function of a complex and bulky assembly developed specifically for "torque vectoring" into two simple and largely conventional units arranged separately from one another. This solution is much cheaper and has more economy of space due to the largely conventional part units which can be produced in large series.